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The Health Effects of Agricultural Pesticides: Are Farmers Willing to Pay?

(Kesan Racun Pertanian ke Atas Kesihatan: Sanggupkah Pesawah Membayar?)

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ABSTRACT

The objective of this study is to estimate farmers' Willingness to Pay (WTP) to reduce the health impacts of pesticide use in rice cultivation in Perlis, Malaysia. The Double-Bounded Contingent Valuation Method was used to estimate the WTP value. A total of 150 respondents were interviewed and distributed according to the number of farmers registered with a Malaysian Agricultural Development Authority, MADA. The results show that four variables, namely gender, education level, income level, and pesticide exposure, are statistically significant in explaining respondents' WTP for safer pesticides. Of these four variables, only gender has a negative sign. Since males represented gender, the negative sign means that male farmers were willing to pay less than female farmers. The results also show that farmers' education level and income have a positive impact on their WTP. Farmers with a higher level of education have a better understanding of the impact of pesticides on human health. Therefore, they have more awareness of reducing these risks, which can be achieved through higher prices for safer pesticides. The positive sign of the income variable indicates that the probability of respondents switching to the use of safer pesticides is positive as their income increases. Respondents are willing to pay a maximum of RM10.22 for safer pesticides. This study extends the existing literature on the impact of pesticides on agriculture by focusing on the monetary value of reducing the health impacts of pesticide use. It also identifies farmers' WTP for safer pesticides. This study has a reference value for safer pesticide use in agriculture. Agencies involved in rice cultivation particularly in Malaysia can benefit from the results of this study. The WTP value can be used as a benchmarking value to improve the current subsidy program for farmers.

Keywords: Rice; pesticides; human health; Willingness to Pay; Contingent Valuation Method.

ABSTRAK

Objektif kajian ini adalah untuk menganggarkan kesanggupan membayar (WTP) pesawah untuk mengurangkan kesan terhadap kesihatan akibat penggunaan racun perosak dalam penanaman padi di Perlis, Malaysia. Kaedah Penilaian Kontinjen Double-Bounded digunakan untuk menganggarkan nilai WTP. Sebanyak 150 responden ditemuramah dan diagihkan berdasarkan jumlah pesawah yang didaftarkan oleh satu badan bagi pembangunan Pertanian di Malaysia, MADA. Hasil kajian menunjukkan bahawa empat pemboleh ubah, iaitu jantina, tahap pendidikan, tahap pendapatan dan pendedahan terhadap racun perosak, adalah signifikan secara statistik dalam menjelaskan WTP responden untuk racun perosak yang lebih selamat. Daripada empat pemboleh ubah ini, hanya jantina yang mempunyai tanda negatif. Oleh kerana jantina diwakili oleh lelaki, tanda negatif bermakna bahawa kesanggupan membayar pesawah lelaki adalah kurang daripada pesawah wanita. Hasil kajian juga menunjukkan bahawa tahap pendidikan dan pendapatan pesawah mempunyai kesan positif terhadap WTP mereka. Pesawah yang mempunyai tahap pendidikan yang lebih tinggi mempunyai pemahaman yang lebih baik mengenai kesan racun perosak terhadap kesihatan manusia. Maka, mereka mempunyai lebih kesedaran untuk mengurangkan risiko ini, yang dapat dicapai melalui harga yang lebih tinggi untuk racun perosak yang lebih selamat. Tanda positif pembolehubah pendapatan menunjukkan bahawa kebarangkalian responden beralih kepada penggunaan racun perosak yang lebih selamat adalah positif apabila pendapatan mereka meningkat. Responden sanggup membayar sehingga RM10.22 untuk racun perosak yang lebih selamat. Kajian ini memperluaskan literatur sedia ada mengenai kesan racun perosak terhadap pertanian dengan memberi tumpuan kepada nilai kewangan untuk mengurangkan kesan terhadap kesihatan akibat penggunaan racun perosak. Ia juga mengenal pasti WTP pesawah untuk racun perosak yang lebih selamat. Kajian ini mempunyai nilai rujukan untuk penggunaan racun perosak yang lebih selamat dalam pertanian. Agensi-agensi yang terlibat dalam penanaman padi di Malaysia boleh mendapat manfaat daripada hasil kajian ini. Nilai WTP boleh digunakan sebagai nilai penanda aras untuk memperbaiki program subsidi sedia ada untuk pesawah.

Kata kunci:padi; racun perosak; kesihatan manusia; kesanggupan membayar; Kaedah Penilaian Kontinjen.

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INTRODUCTION

Rice plantation is an important agricultural sector around the world, including Malaysia. One of its significant roles is to supply staple food for the people in the country. A study by Kasim et al. (2018) found that a Malaysian adult consumes an average of 2.5 plates of white rice per day. The sector also contributes to the country's economy and the livelihood of the population. As stated by Firdaus et al. (2020), forty percent of small-scale farmers' primary income comes solely from rice production. Concerted efforts have been made to increase the quantity and quality of the crop, including the use of the System of Rice Intensification (SRI) method (Dahlgreen & Parr 2024; Setiawan et al. 2014; Uphoff et al. 2011). Planting rice requires a lot of work, and it is not a simple and easy process. Many challenges await farmers - the most significant one they face each season is pest infestation. Infestations have a considerable impact on rice yields, reducing quantity and quality. To protect rice from pest infestation, farmers usually use pesticides.

However, the overuse of pesticides without compliance with application standards and recommendations is harmful to the health of farmers and the environment. The effects are so obvious, especially in the long run. The effects include complications to the skin, nerves, and systems of the human body. Huyen et al. (2020) argued that farmers often suffer from diseases such as eyes, ears, nose, and throat diseases, skin diseases, and gastrointestinal disorders. Wasantha et al. (2023) argued that pesticide induced health problems, thus reduced health capital and increased farm level inefficiency. Anasco et al. (2008) argued that pesticide residues can also damage the food chain ecosystem and consequently cause an imbalance in the relationship between prey and predator. Pesticides can also be toxic to other organisms, including birds, fish, beneficial insects, and nontarget plants, as well as different environmental media, including air, water, soil, and crops (Tudi et al. 2021). The global pesticide consumption in 2019 was approximately 4.19 million metric tons (Fernandez 2021). In southeast Asia, WHO reported an annual increase in pesticide usage, with 20% of developing countries as pesticide consumers, including Cambodia, Laos, and Vietnam (Pathak et al. 2022).

Despite numerous studies on pesticides and health issues conducted worldwide, there is a significant gap in research specifically examining farmers’ willingness to pay for safer pesticides in Malaysia. Although many WTP studies exist (e.g., Nohara 2024; Nitzko et al. 2023; Bernard & Bernard, 2010) and the concept of benefits transfer is permissible for applying WTP values to different study sites, this approach may not be suitable due to varying socio-economic characteristics (See Boyle and Bergstrom, 1992 for more details about benefit transfer). Due to the significant impact of pesticides in rice cultivation on farmers' health and the environment, this paper aims to investigate the extent to which farmers in the Muda Agricultural Development Authority (MADA) area use pesticides. It also aims to determine farmers' Willingness to Pay (WTP) for safer pesticides. The WTP value indicates the additional amount of money farmers are willing to pay for safer pesticides.

The remainder of the study is organised as follows. Section 2 deals with a literature review and background of pesticides used in agriculture. Section 3 describes the methodology used in the study. Section 4 presents the results of the study, in which the main result is the WTP estimated with the Contingent Valuation Method (CVM). Finally, Section 5 draws some conclusions and policy implications.

LITERATURE REVIEW

RICE PESTICIDES

Many researchers have conducted studies on the effects of pesticides on agriculture (e.g., Kaur et al. 2024; Hamsan et al. 2017). These studies fall into at least two distinct categories: human health (Kaur et al. 2024; Wasantha et al. 2023; Huyen et al. 2020; Garming & Waibel 2009) and environmental (Kaur et al. 2024; Tudi et al. 2021), including aquatic ecosystems (Abaineh et al. 2024; Tudi et al. 2021) and terrestrial ecosystems (Sanchez-Bayo 2011). Environmental impacts fall more into the realm of hard science. Since this hard science is not the focus of this study, this section of the literature review will focus on and discuss human impacts. In other words, the impacts on farmers' health.

The contribution of pesticides to agricultural productivity is undeniable (Sarie & Harsono 2024; Atreya et al. 2012; Pingali et al. 1994). However, pesticide use comes at a cost, especially the impact on farmers' health. Pingali et al. (1994), in their study on rice farmers in the Philippines, found that diseases such as eye effects, skin effects, respiratory effects, and gastrointestinal effects were common for farmers who were exposed to pesticide use. For more details on such health effects, see the published work by Hamsan et al. (2017) and Rudzi et al. (2022). Farmers can apply two ways to avoid health risks from pesticides. First, they can follow the authorities' recommendations, such as wearing appropriate Personal Protective Equipment (PPE) when spraying pesticides. However, the use of PPE is not extensive in developing countries, including Malaysia. It is not mandatory, and many farmers do not take the importance of wearing it seriously. This is according to a study by Hamsan (2017). The researcher found that only 8.4% of the respondents wore adequate

PPE. He also found that the use of PPE is merely for skin protection, while less emphasis is given to other important aspects, such as PPE for inhalation.

Second, farmers have the option of using safer pesticides that are obviously less toxic and less harmful to health (Garming & Waibel 2009). Although both options are important and applied in many areas, not many studies have been conducted on the impact of the latter in Malaysia, particularly in terms of farmers' willingness to pay for safer pesticides. A very recent study that investigates the health effects of pesticides on rice farmers was carried out by Izzah Abdul Samad et al. (2024). Using a case study approach, the researchers interviewed 120 respondents in Kota Bahru, Kelantan. The main objective of the study is to assess the potential risks and impacts of pesticide exposure on farmers. The researchers applied the Neurobehavioral Core Battery Test assessment tool for the assessment. Similarly, Sabran and Abas (2021) examined the knowledge and risks associated with pesticide use. Their study found that while the overall awareness level was moderate, the respondents had a high level of knowledge regarding the environmental and health risks of pesticide use. Meanwhile, Jali et al. (2012) examined the impact of pesticides on rice fields and the ecosystem, with a particular focus on farmers' health. Analysing responses from 219 farmers in Selangor, the study found that 51.5% of respondents experienced difficulty breathing after or while spraying pesticides, 26% reported itchiness and sores, and 13.7% had rashes and peeling skin on their hands. Additionally, there were serious cases of farmers collapsing, experiencing stomach aches, and vomiting, which required hospitalization. Jamal et al. (2018) investigated the factors influencing farmers' overuse of pesticides. These factors include the types of pesticides used, the use of protective equipment, safety awareness, the health of pesticide sprayers, and the use of excessive pesticide doses. The authors also applied logit regression to determine the factors influencing rice farmers' pesticide behaviour and compliance. However, none of the variables considered was the willingness to pay for safer pesticides.

Many more studies have been carried out on pesticides and rice, but only a few have been undertaken on estimating the willingness to pay value. Researchers (e.g., Pecenka et al. 2021; Artreya et al. 2012; Wilson 2005) have used various techniques (e.g., defence expenditures, Integrated Pest Management (IPM), disease costs, etc.) to assess the impact of pesticides on human health. However, the focus of this paper is on estimating the monetary value of health risks caused by pesticides using the Contingent Valuation Method (CVM), as done by Khan (2009) and Garming & Waibel (2009) in their study. To the best of our knowledge, the latest was conducted by Mohd Amir as part of his PhD thesis in 2012. Since then, no other study has been conducted that specifically uses CVM.

STATED PREFERENCE TECHNIQUE

Environmental valuation is a technique for assigning a monetary value to goods and services that are not traded in the marketplace. Two approaches can be used to estimate such values: Willingness to Pay (WTP) or Willingness to Accept (WTA). The technique has been applied by many researchers (Muslim et al. 2023; Costanza & Folke 1997) in valuing environmental assets such as mangrove forests (Hasan-Basri et al. 2020) or renewable energy (Bergmann et al. 2008) and has since gained popularity. Two broad categories - indirect or direct - can be applied to estimate the value, the difference between them being how the WTP(A) value is elicited from respondents. The direct category is used when the WTP question asks respondents directly about the value (i.e., how much are you willing to pay for better air quality?). The indirect category, on the other hand, is a way of estimating price based on other information such as expenses (e.g., cost of gasoline and groceries, travel time, entrance fees) that consumers must incur or pay to enjoy the environmental goods and services.

Researchers are most commonly applying two methods in a direct category. They are Choice Experiment (CE) and the Contingent Valuation Method (CVM). Though both methods rely on hypothetical questions, the methodological requirement for the prior seems more complicated than the latter. CE uses attributes to describe environmental goods to respondents. To mimic goods in a marketplace, researchers usually create various levels for each attribute. A combination of different attributes at various levels is a hypothetical good. Such a hypothetical good will be presented against other hypothetical goods to respondents. Then, respondents will be asked to choose a hypothetical good that will maximise their utility. Supposedly, all relevant attributes and their levels should be included so that hypothetical goods can be generated in the full factorial design. However, this is not the case. Most studies (i.e., Hasan-Basri et al. 2020; Mohamad et al. 2023) employed a fractional factorial design. Fractional means focusing on the means effect of each attribute. That is one of the drawbacks of the CE.

CVM differs from CE. The method does not need attributes and their levels as required in CE. The survey design is simple and easy for researchers to apply. They typically involve a single question about WTP. CVM survey also asks respondents for direct monetary valuation. Respondents are required to answer whether they are willing to pay a certain amount of money based on hypothetical scenarios presented to them. Having said that, it is a straightforward approach where respondents will be asked a direct question such as "Are you willing to pay RM20 for safer pesticides?". In a nutshell, the method demands less cognitive load to process information.

There are several ways to ask respondents to pay (see Mitchell & Carson 1989 for details), but the method used in this paper is the Double-Bounded CVM (DBCVM). The DBCVM has received the full endorsement from the National Oceanic Atmospheric Administration (NOAA) (Portney 1984) for use in CVM. As the name implies, the double-bounded process is a two-round process used in contingent valuation studies to determine the WTP of individuals for a particular good or service. As explained by Hanemann et al. (1991), it serves to overcome some of the biases and hypothetical biases associated with single-bounded questions. In the first round, respondents are presented with an initial bid for the good or service in question. If the respondent is willing to pay the initial bid price in the first round, he or she must answer the second bid price. In the second round, the respondent is presented with a higher bid price. The purpose of this DBCVM is to determine the maximum amount of money the respondent is willing to pay. However, if the respondent refuses to pay the original offer price in the first round, he or she will be asked the question in the second round as well. In this case, however, respondents are presented with a lower bid price, and the objective is to determine the minimum amount they are willing to pay. The double-bounded method allows researchers to obtain more reliable estimates of respondents' actual WTP for the safer pesticide as it takes into account the potential price range that individuals are willing to pay.

METHODOLOGY

STUDY AREA

MUDA is the largest granary area in Malaysia. Managed by Muda Agricultural Development Authority (MADA), the area covers 130,282 hectares, of which 100,685 hectares are planted with rice. To facilitate the distribution of water from Pedu Dam, MADA has divided the area into four regions: Region [1] (Perlis), Region 2 (Jitra), Region 3 (Pendang), and Region 4 (Kota Sarang Semut). All regions are shown in Figure 1. Region 2 has the largest area with 32,595 hectares, followed by Region 4 (25,335 hectares), Region 3 (22,682 hectares), and finally Region 1 with 20,073 hectares. However, this study on the impact of pesticide use on farmers' health focuses only on Region 1. Region 1 was chosen as the study area because of three reasons. First, Perlis's economy is highly based on agriculture, particularly in rural areas. The dependence on rice cultivation emphasizes the significance of maintaining and improving this sector for the benefit of the local population. Second, Perlis agricultural sector productivity (RM69,900) is three times higher than the national average (Perlis Strategic Development Plan 2012-2030, 2013). Third, the average rice production in the MUDA area remains low when compared to other major rice-growing locations in Malaysia. This should not happen because the MUDA Irrigation Project receives the largest subsidy allocation, accounting for almost fifty percent of the total subsidies received each year (Ismail & Abdul Rahim 2019). Thus, it is worth investigating this region.

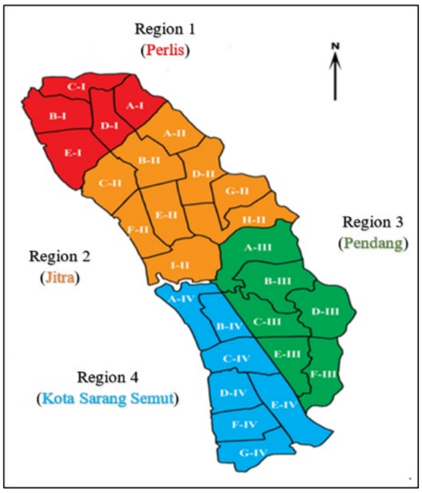

FIGURE 1. Areas of Muda Agricultural Development Authority (MADA)

QUESTIONNAIRE DESIGN

The study uses a questionnaire to obtain information from respondents. The development of the questionnaire began with desktop research in which relevant articles published in good journals were reviewed. From those findings, we formulated questions regarding the types of pesticides commonly used in rice plantation, the health issues related to pesticide exposure, and their respective prices. To investigate their suitability, we presented the questions to stakeholders seeking their opinions. The questionnaire is divided into three sections, and different information is collected in each section. Section A collects information about respondents' socio-economic circumstances, including gender, education, age, and health status. Section B collects information on rice plantation, such as yields, planting area, type of pesticides used, etc. The last section, C, asks respondents to indicate whether they are willing to pay for safer pesticides.

Section C contains a hypothetical market script that enumerators read to respondents before asking them to answer the DBCVM questions. The script is shown in Figure 2. As explained in the CVM section, the respondents in this study were required to answer two-round "yes or no" contingent valuation questions. Four level bid prices were used in the study: RM 5, RM 10, RM 15, and RM 20. Such values were determined based on a series of meetings with farmers. The maximum and minimum bid prices in the study were RM40 and RM5. Some farmers pay a higher price for pesticides, while others do not. Based on the market survey, we concluded that the average price was RM49.00 for Class II[1], RM53.00 for Class III, and RM134.00 for Class IV. To account for these different pesticide prices, respondents were asked to indicate their willingness to pay as a function of their current pesticide price. To illustrate, if respondents use pesticides in Class III, they were asked to indicate whether they would be willing to pay an additional RM15 (bid price) on top of the price they are paying now (RM53.00).

> Farmers use pesticides to protect their rice from pest infestation. However, the overuse of pesticides leads to harmful effects on themselves. There is one report published previously on the impact of pesticides on farmers' health. The study, conducted on rice farmers exposed to pesticide spraying, found that many farmers suffered from itchy and peeling skin, and red spots after pesticide spraying. And 90% of them reported having back pain.
>
> One way to protect farmers' health is to require them to use safer pesticides. The use of safer pesticides has many benefits, such as increasing rice yield, low residues, maintaining the population of beneficial insects, not polluting the environment, and less toxic to farmers' health. Based on our market survey, we found that the average unit price of Class II pesticide is RM48.67, Class III is RM53.00 and Class IV is RM134.33. In the following contingency questions, we would like to ask you if you are willing to pay voluntarily an additional amount for safer pesticides. Keep in mind that this additional fee will affect your income.

FIGURE 2. Hypothetical scripts of Double Bounded Contingent Valuation Method (DBCVM)

CONTINGENT VALUATION METHOD

The dependent variable of DBCVM questions takes a binary value - yes or no - and is analysed with a Random Utility Model (RUM) (refer to Haab & McConnell 2003 and Bateman et al. 2002 for more details). Suppose respondent j's utility function is given in Eq 1:

$$U_{ij} = U_i(y_j, z_j, \varepsilon_{ij}) \qquad (1)$$

where *i* refers to the use of safer pesticides. It takes the value 0 for the status quo scenario (i.e., business as usual) and the value 1 if respondents plan to use safer pesticides. While y is household income, z is a vector of respondents' characteristics, and ε is the unobservable. We can argue that respondents are willing to pay (or to say yes to DBCVM questions) if their utility of using safer pesticides is greater than their current utility. Technically, the probability of saying yes is shown in Eq 2:

$$Prob(Yes_j) = Prob\ (U_1(y_j - d_j, z_j, \varepsilon_{1j}) > U_0(y_j, z_j, \varepsilon_{0j})) \qquad (2)$$

where d_j is the bid price. By employing the maximum likelihood (ML) method, the coefficients can be estimated with the logit model, as shown in Eq 3.

$$P_i\,(yes) = \frac{1}{1+\exp[-(\alpha - \beta A)]} \qquad (3)$$

where α and β are coefficients to be estimated using the ML estimation method, and A is the bid amount that respondents are asked to pay in the DBCVM context. The availability of estimates permits us to calculate the WTP value as in Eq 4.

$$\text{Mean WTP} = -\alpha/\beta \qquad (4)$$

DATA SAMPLING

A face-to-face survey was conducted for six weeks, starting from mid-December 2022. With the assistance of five trained enumerators, respondents were guided to answer each question on the questionnaire. The survey was conducted in two sessions - morning and afternoon - usually after the respondents had finished their work in the rice field. The respondents were selected based on a stratified sampling technique in which we used the number of registered farmers in Region 1 as the selection criterion. The following sentences illustrate how the stratified sampling was applied in the study. The MADA record shows that Region 1 consists of five compartments, namely Arau, Kayang, Kangar, Tambun Tulang, and Simpang Empat. For each compartment, there are some registered farmers with MADA. For instance, out of a total of 9,191 registered farmers, 1,312 (or 14%) are located in the Arau compartment. To ensure that the surveyed respondents represented the study area, 14% of the study's respondents must come from the Arau compartment. Thus, based on 150 target respondents, the total number of respondents from Arau is 21. To the best of our knowledge, there is no scientific analysis in the environmental economics literature determining an appropriate sample size for the CVM study. We may find a CVM study that interviewed 114 respondents (Puspitasari et al. 2024) or 45 respondents (Etuk et al. 2024). Table 1 shows the details of farmers registered with MADA and the surveyed respondents.

TABLE 1. Surveyed respondents

Area	Number of farmers	Sample
Arau	1, 312	21
Kayang	2, 128	35
Kangar	1, 355	22
Tambun Tulang	1, 817	30
Simpang Empat	2, 579	42
Total	9, 191	150

RESULTS AND DISCUSSION

SOCIO-ECONOMIC INFORMATION

Table 2 presents the socio-economic information of the respondents. After screening and cleaning the data collected, we decided that all responses collected from 150 respondents were valid for analysis. Most of the respondents were men (94.67%), and we found that the tasks related to rice plantation (i.e., lifting bags of rice seeds, carrying pesticide spray pumps, and lifting water pumps) were more suitable for them. Regarding the age group of the respondents, the majority of them were from the age group 61 years and older (47%), followed by the age group 41- 60 years (41%), and the least from the age group 21- 40 with 11%. Seventy-five percent (75%) of the respondents are considered experienced farmers based on the number of cultivation years. They have been planting rice for more than ten years. For the cultivated areas that we measured in *relong*[2], the data shows that almost 60% of them have cultivated five *relong* or less.

We noticed that household income is an important factor in determining farmers' willingness to pay for safer pesticides. The commitment to pay will affect their disposable income. Therefore, it is important to know the income level of the respondents. Before discussing the income level, it is worth mentioning that 67% of the respondents depended on rice cultivation as their main source of income. 59% of them were owners, and the rest were rented from others. Rice yields (measured in tons per season) show that 27% of respondents harvested less than 5 tons, 30% harvested between 5.1 and 10 tons, and the rest harvested more than 10 tons. However, after subtracting rice expenses, we found that farmers' income groups per season were distributed as follows: 3% with income less than RM5,000, 20% of respondents with income between RM10,001 and RM15,000, and RM15,001 to RM20,000. For the two income groups RM20,001 to RM25,000 and RM30,000 and above, the results were 10% and 28%, respectively.

Farmer's education is a very important variable in understanding their commitment to using safer pesticides. Hypothetically, the tendency to use safer pesticides is congruent with education level. In other words, we hypothesise that the higher the level of education, the greater the propensity to use safer pesticides. Table 2 shows that more than 80% of the respondents had at least 11 years of formal education. The data on farmers' use of pesticides are presented in the following sections.

We also asked about the farmer's current health status. We listed illnesses related to pesticide use, such as dizziness, headaches, fainting, respiratory problems, etc. The survey data show that 14% of the respondents had no illness, 45% had at least two illnesses, 27% had three to four illnesses, and 13% had five or more illnesses. The most common illness was dizziness at 82%, followed by headache (54%), watery eyes (48%), and fainting at 22%. Other illnesses were reported at 10% or less.

TABLE 2. Socio-economic of respondents (n=150)

Variables	Groups	Frequency	Percentage
Gender	Male	142	94.67
	Female	8	5.33
	Total	150	100
Age (years)	21-30	4	2.67
	31-40	13	8.67
	41-50	24	16.00
	51-60	38	25.33
	61-70	51	34.00
	More than 70	20	13.33
	Total	150	100
Cultivation period (years)	Less than 10	38	25.33
	11-20	58	38.67
	21-30	23	15.33
	31-40	15	10.00
	41-50	14	9.33
	51-60	2	1.33
	Total	150	100

MADA	Arau	21	14.00
	Kayang	35	23.33
	Kangar	22	14.67
	Tambun Tulang	32	21.33
	Simpang Empat	40	26.67
	Total	150	100
Cultivation area (relongs)	Less than 5	89	59.33
	5.1-10	46	30.67
	11-15	10	6.67
	16-20	1	0.67
	21-25	2	1.33
	More than 25.1	2	1.33
	Total	150	100
Rice yield (tons)	Less than 5	41	27.33
	5-10	45	30.00
	10-15	34	22.67
	15-20	14	9.33
	20-25	7	4.67
	25-30	5	3.33
	More than 30	4	2.67
	Total	150	100
Source	No	50	33.33
	Yes	100	66.67
	Total	150	100
Income/season (R.M.)	Less than 5000	4	2.67
	5001-10000	29	19.33
	10001-15000	30	20.00
	15001-20000	30	20.00
	20001-25000	15	10.00
	25001-30000	12	8.00
	More than 30001	30	20.00
	Total	150	100
Ownership status	Own	119	59.20
	Rent	82	40.80
	Lease	0	0
	Total	201	100
Education (years)	0-6	27	18.00
	7-11	98	65.33
	12-14	20	13.33
	More than 14.1	5	3.34
	Total	150	100
Health problems	0	21	14.00
	1-2	68	45.33
	3-4	41	27.33
	More than 5	20	13.33
	Total	150	100

FARMERS' USE OF PESTICIDES

This section explains the results related to farmers' use of pesticides, including types (or grades) of pesticides, financial costs, and application of PPE. The results in Table 3 show that 58% of respondents use prohibited pesticides (class I.A. and I.B.). Although this class (i.e., I.A.) is considered the most harmful (Baharom 2019), the demand from farmers is high due to its efficiency in preventing attacks on golden apple snails. These results are not consistent with the assumption about the educational level of farmers that we made earlier. Regarding pesticide expenditure, we found that 55% of the respondents spent less than RM500 per season on pesticides. 30% spent between RM501 and RM1000, followed by 11% (RM1001 to RM1500) and finally 3% for RM1501 and above. For pesticide spraying, many respondents (77%) reported using the traditional method.

The number of days farmers spend using pesticides (i.e., Management Practice) in the rice field is another contributing factor to farmers' health. Survey data showed that 69% of respondents were exposed to pesticides at least three days a week. The rest were not exposed at all because they hired a worker to spray the pesticides or used a drone service. The final issue is compliance with personal protective equipment (PPE). Three measures of PPE were investigated in the study, and the results are as follows: respondents wear full PPE (61%), respondents wash PPE after use (75%), and never eat or drink while spraying (73%).

TABLE 3. Tabulates of pesticide use

Criteria		Groups	Frequency	Percentage
Class of Pesticide	Class I.A	Never	9	6.00
		Rarely	14	9.33
		Sometimes	42	28.00
		Very often	85	56.67

	Class I.B	Never	77	51.33
		Rarely	48	32.00
		Sometimes	23	15.33
		Very often	2	1.33
Safety and Personal Protective Equipment	Wear PPE	Never	1	0.67
		Rarely	9	6.00
		Sometimes	49	32.67
		Very often	91	60.67
	Wash PPE	Never	0	0
		Rarely	5	3.33
		Sometimes	32	21.33
		Very often	113	75.33
	Never Eat/Drink	Never	110	73.33
		Rarely	33	22.00
		Sometimes	7	4.67
		Very often	0	0
Management Practice (days)		0	25	16.67
		1-2	22	14.67
		3-4	76	50.67
		More than 5	27	18.00
Pesticide Spending		Less than RM 500	83	55.33
		RM 501-RM 1000	45	30.00
		RM 1001- RM 1500	17	11.33
		More than RM 1501	5	3.34
Methods of Spraying Pesticide		Manual	115	76.67
		Drone	12	8.00
		Manual and Drone	23	15.33

BID PRICE AND WILLINGNESS TO PAY

Three average base prices for pesticides were used for the study: Class II (RM50.00), Class III (RM53.00), and Class IV (RM135.00). Based on their current spending on pesticides, respondents were asked if they would be willing to pay an additional amount of money for safer pesticides. The additional bid prices were randomly selected for them. As explained in the methodology section, four bid prices were used - RM5.00, RM10.00, RM15.00, and RM20.00, with a maximum price of RM40.00 and a minimum of RM1.00. To illustrate how the maximum and minimum prices were applied - suppose the respondents were shown a bid price of RM20.00, and they were willing to pay; the highest bid price would be RM40.00. If they were shown a bid price of RM5.00 and they were not willing to pay it, the lowest bid price would be RM1.00. The next question is how we translate such responses into Yes-No or No-Yes coding. Referring to the latter, if the respondents were not willing to pay the bid price of RM5.00 on the first bid but were willing to pay RM1.00 on the second bid, then it is No-Yes.

The four bid prices were similarly distributed to all 150 respondents. This means that 37 or 38 respondents answered each bid price. Table 4 tabulates the respondents' answers to the double-bounded CVM questions. When we examine column 3, Y.N. (%), the data clearly follows the demand rule theory. When the bid price increases, respondents' willingness to pay decreases. The data shows that the respondents' willingness to pay decreases from 13% to 11% when the bid price increases from RM5.00 to RM10.00. The same results were found for other bid prices.

TABLE 4. Respondents' responses to the double-bounded contingent valuation method

Bid Price (R.M.)	N.N. (%)	N.Y. (%)	Y.N. (%)	Y.Y. (%)
5	1.33	1.33	13.33	8.67
10	5.33	4.67	10.67	4.67
15	12.67	4.67	6.67	0.67
20	19.33	2	4	0
Total	38.66	12.67	34.67	14.01

Table 5 shows the logit model coefficients of the DBCVM after the data were regressed in Stata version 12. The WTP function is shown in Equation 5:

$$WTP = f(\, d_{male}, age, edu, health, inc, fsize, smeasure, exposure) \qquad (5)$$

d_{male} is a dummy variable where 1 represents a male respondent, *age* refers to the respondent's age, and *edu* is the respondents' formal years of schooling. *Inc* is the respondent's income from rice cultivation per season, and *fsize* is the size of a rice field. *smeasure* and *exposure* are safety measures related to the respondent's PPE and the number of days the respondent was exposed to pesticides, respectively. The values of Wald Chi-Sqd statistics exceeded the critical values. This means that there is at least one coefficient whose value is non-zero when estimated together with the other coefficients. The coefficient for sigma was also significant at the 1% level.

The results show that four variables: gender, years of education, income level, and pesticide exposure are significant, at least at the 10% level. This means that the variables are statistically significant in explaining respondents' willingness to pay for safer pesticides. Of these four variables, only gender has a negative sign. Since males represented gender, the negative sign means that male farmers were willing to pay less than female farmers. The results also show that farmers' education level and income earned from rice cultivation have positive effects on their WTP. Logically, farmers who have achieved a higher level of education have a better understanding of the effects of pesticides on human health. As a result, they are more concerned about reducing these risks, which can be achieved through higher prices for safer pesticides.

We got the same result for income levels. According to the Environmental Kuznet Curve (EKC) hypothesis, the demand for health or environmental benefits is expected to increase as income increases. The coefficient of income was found to be highly significant at the 1% level in this full logit model regression. Therefore, respondents who earn a higher income from rice plantations are more willing to pay more for safer pesticides. These results are consistent with previous research (Wang et al. 2018). In terms of WTP value, CVM analysis reveals that respondents are willing to pay RM10.22 in addition to the current expenditure on pesticides. However, when respondents are given the choice of paying more for safer pesticides and high-quality rice seeds, the results show that 75% of respondents prefer the latter to the former. Such results were expected because high-quality rice seed can prevent the occurrence of weedy rice. Farmers are more concerned about weedy rice.

According to a report by Perlis Strategic Development Plan 2012-2030 (2013), Perlis has an important role in the country's food security. This food security starts from the farm. Food security is also closely related to the use of pesticides, where these pesticides can protect rice from pest attacks and improve crop quality and yield. The use of pesticides that are not appropriate and do not follow good agricultural practices can cause harm to users, operators, and the environment.

TABLE 5. Logit coefficients of double-bounded CVM

	Coefficient	Std. err	z	P>z	[95% conf. interval]	
Beta						
Male	-4.379822	2.45874	-1.78	0.075	-9.198864	.4392203
Age	.1195496	.474582	0.25	0.801	-.8106139	1.049713
Education	2.019228	1.037296	1.95	0.052	-.0138349	4.052291
Health	-.9253287	.8105729	-1.14	0.254	-2.514022	.6633649
Income	1.025669	.3869202	2.65	0.008	.2673199	1.784019
Farm size	-.5094267	.7152955	-0.71	0.476	-1.91138	.8925268
Usage	-.2146042	1.181711	-0.18	0.856	-2.530716	2.101507
Safety measure	-1.471389	2.122399	-0.69	0.488	-5.631215	2.688437
Management practice	1.382221	.6998426	1.98	0.048	.0105547	2.753887
_cons	6.277068	5.084371	1.23	0.217	-3.688116	16.24225
Sigma						
_cons	5.51173	.5063994	10.88	0.000	4.519205	6.504254
WTP	10.21881	.5429222	18.82	0.000	9.154704	11.28292
Number of obs			150			
Wald chi2(9)			28.40			
Prob > chi2			0.0008			
Log-likelihood			-153.43176			

CONCLUSION

The role of pesticides in the rice sector can be best described as a coin with two sides. On one side, they contribute to rice productivity, which has been scientifically proven and studied by many researchers (e.g., Sarie & Harsono 2024; Pingali et al. 1994). However, on the other side, it also has negative effects on human health and the environment (e.g., Kaur et al. 2024; Wasantha et al. 2023; Huyen et al. 2020). The human health studies conducted to date have focused mainly on the effects of pesticide residues on the public in general. It can be the effect on water storage that is eventually linked to the effect of drinking water quality. This paper, however, focuses on the effects of pesticides on farmers' health. We calculated the impact on monetary value, where the value was estimated based on farmers' willingness to pay for safer pesticides.

The results of this study show that the health problems of the respondents are quite disturbing. One way to mitigate the problem is to encourage them to use safer pesticides. We ask them to indicate their willingness to pay for safer pesticides that have less impact on their health. A total of 150 respondents were interviewed in person by trained enumerators in Perlis. The results of the double-bounded contingent valuation model analysis show that the important income variable is significant at the 1% level. This indicates that respondents are fully aware of the impact of their income on their willingness to pay. The variable has a positive sign, indicating that the likelihood of respondents switching to using safer pesticides is positive as their income increases. The results also show that respondents are willing to pay a maximum of RM10.22 for what they currently pay for safer pesticides. For example, if the respondent uses class III pesticides that cost her RM53.00, the results show that she is willing to pay RM10.22 more for safer pesticides.

Agencies associated with the rice sector in Malaysia can benefit from the results of this study. For example, they can use the WTP value as a benchmarking value to improve the current subsidy programme for farmers. Rice plantations in Malaysia are experiencing serious problems. Most rice farmers are now old farmers. Some of them have been working on the plantations for more than 20 years and are not as strong as in previous years. To make matters worse, most of their children are no longer interested in continuing their parents' work. An interesting subsidy programme would hopefully encourage more farmers to plant rice. Such an effective rice subsidy programme could be further explored in a future study.

Reducing reliance on harmful insecticides can promote a healthier environment and safer food production. This is in line with the third Sustainable Development Goal 3, which aims to ensure healthy lives and promote well-being for all ages. By using safer insecticides in rice farming, Perlis may make significant progress toward SDG 3. Healthier methods of farming improve health conditions for farmers and their families, lower healthcare expenses caused by insecticide-related illnesses, and contribute to general community well-being.

The results of the study, however, should be applied cautiously. This is due to the method used, the hypothetical CVM, which is susceptible to hypothetical bias issues. For instance, the results show that the respondents were willing to pay extra for safer pesticides. However, the farmers' behaviour might be different in a real marketplace. This is known in the CVM literature as response bias. Apart from that, the quality of the information provided to respondents can significantly affect respondents' responses. Thus, DBCVM is not a foolproof solution for determining the amount of money that farmers are willing to pay for safer pesticides. It would be worth the effort if researchers could obtain the farmers' actual medical expenses due to pesticide use. Such expenses can be compared with the WTP value results.

NOTES

1 For now, there are four classes of pesticides available in the market. They started with Class I and ends with Class IV. The rank, in a particular order reflects to the grade of pesticides and their impact to human health. Class IV is considered the safest pesticides. Class I is prohibited from being used in the rice sector by the authority agencies, thus it was not included in this study.

2 A unit of land area of 30,876 square feet, approximately 2870m^2 (approximately 0.711 acres).

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